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ABSTRACT

This paper examines and tests the assumptions that a curriculum which adequately portrays instructional strategies (related to teaching the nature of science, science curricular content, and teachers' views of the nature of science) will increase students' understanding of the nature of science. This study was conducted over a 16-week period. A pretest-posttest nonequivalent-groups design was utilized to investigate seven research hypotheses. Three independent variables examined included teachers' conceptions of the nature of science, the use of instructional strategy, and the use of curricular content. The dependent variable was the students' scores on the Nature of Scientific Knowledge Scale. Results indicated that teachers with a high understanding of the nature of science were found to reflect the instrumentalist nature of science in their teaching practices. One implication is the importance of the instructional strategy in promoting students' understanding of the nature of science. (Contains 27 references.) (CCM)

Looking Forward, Looking Backward: An Investigation of Students' Understanding of the Nature of Science

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The National Science Education Standards among others have recognized that consideration of the nature of science is central to many aspects of reform in science education. The development of science curricula, instructional strategies, assessment techniques and teacher education programs, are all influenced by our implicit and explicit views of what science is like and how it works (AAAS, 1993; NRC, 1996: NSTA, 1997). It is essential to consider what counts as "the nature of science." While there are some contradicted studies related to the nature of science, it seems inevitable that this area will receive greater attention in the future.

Research related to teachers' and students' understanding of the nature of science presented various interpretations of what aspects characterize the nature of science. Earlier research efforts of 1960s and 1970s the nature of science, mainly from governmental involvement such as the National Science Foundation (NSF), were seen to be lacking a true call for the nature of science for all students. Those initiatives viewed the nature of science as internal concern to scientist and students majoring in sciences (Forawi, 2000). The National Science Foundation (NSF) advocated for more rigorous science curricula and in school. Currently, views of science provide a complex picture of science as a dynamic human enterprise that takes place in a rich social and historical context. Discussion of the nature of science has coincided historically with a widespread reassessment of the basic goals of science instruction (Turner & Sullenger, 1999).

For years, the decline in high quality science programs has been a source of concern to educators and policymakers which led to the reexamination of the status of science education in schools (NRC, 1996). Instruction in the nature of science is not enough to enhance students' understanding of science; teachers' conceptions of the nature of science also play a major role. Students' naive understandings of the nature of science have been attributed to science curricular materials and instructional practices which do not adequately reflect the nature of scientific knowledge (Zeidler & Lederman, 1989; Meichtry, 1993). Considerable work has recently been undertaken to understand the role of teachers' content knowledge in classroom instruction (Alters, 1997). However, the role of teachers' understanding of the nature of science and its interaction with other variables related to students' understanding of the nature of science has not been fully examined.

The literature points to the need of empirical evidence of the success of innovative instructional materials and techniques designed to facilitate more adequate understandings of the nature of science (Brickhouse, 1990; Finley, Lawrenz, Heller, 1992; Mathews, 1997). Science educators have recommended curriculum changes and instructional strategies based on most up-to-date theories. However, a study by Meichtry (1992) has found that the Biological Sciences Curriculum Study (BSCS), a program designed to facilitate a better understanding of the nature of science, did not increase students' understanding. It appears that an obstacle to students' achieving a widely accepted dimension of scientific literacy and adequate understanding of the nature of scientific knowledge, is the combined teacher's inadequate understanding of the nature of science and instructional choice. Thus, investigating the effects of the interaction of the instructional strategies related to teaching the nature of science, science curricular content, and teachers' views of the nature of science is warranted.

Since the high school level represents a critical time for developing student's attitudes toward science, teachers' understanding of the nature of scientific knowledge is deemed an important aspect in teaching science. This study investigated the interaction effects of these three main variables which may help in developing the appropriate curriculum and instructions for promoting students' understanding of the nature of science.

A better understanding of the nature of science cannot be achieved until identification and examination of possible contributing factors to this understanding can be made. Some investigators, (Flick & Dickinson, 1997; Finley, Lawrenz, Heller, 1992; Forawi, 1998; Lederman, 1992), have looked for a significant correlation between students' understanding of the nature of science and other factors such as instructional strategies, language used in the classroom, content knowledge, and teachers' views of the nature of science. All of these studies shared a common assumption that a science curriculum which does not portray instructional strategies related to teaching the nature of science, science content, and teachers' views of the nature of science will not adequately affect students' views of the nature of scientific knowledge. However, the merit of that assumption and the interaction of these factors in terms of affecting students' understanding of the nature of science have not been sufficiently investigated. The relatively small number of these studies, as well as the inconsistency of their findings, provided a rationale to perform further investigations.

Purpose

The purpose of this study is to examine and test the assumption that a curriculum which adequately portrays instructional strategies related to teaching the nature of science, science curricular content, and teachers' views of the nature of science will increase students' understanding of the nature of science.

Research Questions

Science educators are responsible for presenting an adequate view of scientific knowledge to students. The focus of current science curriculum recommendations is to improve students' views of the nature of scientific knowledge. It is imperative to recognize the adequacy of teachers' conceptions of the nature of science and their interaction with instruction and curricular materials in achieving these desired goals. This study investigates two questions: 1) what instructional strategies are associated with more instrumentalist understanding of the nature of science? and 2) What are the effects of the interaction of instructional strategy, science curricular content, and teachers' understanding of the nature of science on students' understanding of the nature of science?

Rationale

Scientific literacy is widely stated as a goal of science education (AAAS, 1999; NRC, 1996). As the world becomes increasingly scientifically oriented, individuals need an adequate understanding of science. The emphasis of school science on vocabulary and concepts revised knowledge discounting the essence of scientific enterprise (Alters, 1997). Traditionally the approach to teaching science has been to teach a body of organized knowledge. With the accumulation of so much scientific knowledge, however, this traditional method is no longer a logical basis for organizing curriculum (Martin, 1997). Through the use of step-by-step type laboratory activities, hypotheses are viewed as simple guesses and theories are believed to be proven by objective direct observations and easy yes/no analysis (Forawi, 2000; Hodson, 1988). Scientific laws are taught to students as validated established theories.

These current pedagogical methods distort the nature of scientific knowledge by providing a simplistic view of a very complex humanistic enterprise. The result of the continuing usage of traditional instructional techniques and curriculum materials will have negative consequences on students' development of the instrumentalist nature of science. With the rapid rate at which knowledge is expanding, it has become tenuous to prescribe which concepts should be transmitted to students in their 12 or more years of formal education (Rakow, 1986). Identifying the instructional strategies related to the nature of science would explain the possibility of a teaching approach that promotes an instrumentalist understanding of the nature of science. Also, another rationale would be the accountability for the interaction of major factors of the nature of scientific knowledge. Researchers studying the nature of science are remiss in not paying attention to such relationships.

Definition of Terms

The major key terms of this study to be defined are: The nature of science, the instrumentalist view, inquiry and traditional teaching approaches, and the Biological Sciences Curriculum Study (BSCS). These major terms are defined as follows: The Nature of Science: The nature of scientific knowledge is defined as amoral, creative, developmental, parsimonious, testable, and unified (Rubba & Anderson 1978). The Instrumentalist View: The instrumentalist (antirealist) view represents scientific knowledge as a product of human imagination and creativity. It allows us to make inferences and construct arbitrary models to explain the behavior of physical phenomena (Munby, 1976). Inquiry Teaching Approach: Inquiry teaching approach is based on the premise that students can be inquirers in the classroom and can generate meanings independently by examining a variety of available learning materials, and with a minimum of teacher guidance (DeBoer, 1991). The Biological Sciences Curriculum Study (BSCS): The BSCS program emphasizes biology as developing, self-revising process rather than as a body of authoritative facts and dogma. Its laboratory activities are designed in such a way that the student learns the techniques of inquiry and the nature of the scientific process through self-discovery and direct experience (BSCS, 1990). Traditional instruction: It refers to expository or lecture teaching where there is a minimum of student's involvement and maximum teacher's dominance (Martin, 1998).

Method

The study was conducted over a 16-week period. A pretest-posttest nonequivalent-groups design was utilized to investigate seven research hypotheses. Three independent variables were examined- teachers' conceptions of the nature of science (Tnos), the use of instructional strategy (Inst), and the use of curricular content (Text). The dependent variable was the students' scores on the Nature of Scientific Knowledge Scale (NSKS).

Sample

Teachers:

First, the researcher selected ten schools that used the Biological Sciences Curriculum Study (BSCS) textbook and ten schools that used textbooks other than the BSCS (nonBSCS). The Biological Sciences Curriculum Study textbook, in all its versions, is purported to enhance understanding of the nature of science. The level of use of the BSCS textbook, the blue version, in all participating schools was determined by selecting only those teachers who indicated a 75% or more level of usage for homework assignments, chapter readings, laboratory activities and evaluation techniques. Therefore, the textbook and companion activities were considered as the primary source of classroom and laboratory work in classes. The non-BSCS or conventional textbooks did not include any textbooks that have major emphases on the nature of science. This process identified some schools as BSCS and others as non-BSCS that were included in the following step.

Second, the researcher and another trained coder identified teachers' classroom instruction of those schools identified as BSCS and nonBSCS following the Instructional Strategy Identification Form (ISIF) for distinguishing the inquiry-oriented approach and the traditional instructional approach.

Finally, the two procedures, selection of teachers' instructional strategies and textbooks, reduced the number of teachers in the participant schools that were included to administer the Nature of Scientific Knowledge Scale (NSKS) which identified teachers as having adequate (high) or inadequate (low) conceptions of the nature of science. As the result, eight teachers were selected to participate in this study. Four teachers used non-BSCS textbooks and another four used the BSCS textbook. While two teachers in each group had high understanding of the nature of science as measured by NSKS instrument, another two had low understanding of the nature of science. Each one of these two teachers used a different teaching approach, traditional or inquiry.

Students:

After teachers were selected for each group, two tenth grade classes for each of these teachers totaling 320 students were chosen to compose the student groups in order to ensure greater homogeneity of sample. Only regular tenth grade classes were included in these groups. The students in each one of these classes were treated as intact groups. The dropout and entering students during the length of the study were excluded. The Nature of Scientific Knowledge Scale (NSKS) was used to measure students' pre and posttest scores. Therefore, the study was composed of eight homogeneous intact tenth grade biology groups in six schools in the eastern part of the United States. Each group was composed of approximately forty students. Urban and suburban schools were included to cover range of sex, race, and a socioeconomic diversity within the sample.

Instrumentation

The study utilized two assessment instruments that are described as follows.

1- Instructional Strategy Identification Form (ISIF): Classroom observations were conducted to identify those teachers with inquiry-oriented teaching approach and those with traditional teaching instruction. The researcher modified the criteria for distinguishing inquiry from traditional instructional strategies described by Youssef (1977) to incorporate items that operationally distinguish the two different teaching approaches. These major features of the Instructional Strategy Identification Form (ISIF) include: introduction of lesson, presentation of information, fragmented presentation, frequent questioning, level of questions, teacher probing, decision- making, student participation, student attentiveness, methods employed, teacher role, laboratory work, activities, reading, tests, and other forms of evaluation. Using any one of these features as described in traditional orientation was considered one point, and using it in an inquiry orientation was considered three points, while two points were given when the instructional practice tended to be more than traditional practice and partially an inquiry orientation.

In the ISIF scoring form, all statements with the letter "a" in each instructional feature that describe traditional teaching approach were rated as: no emphasis = 0, slight emphasis = 3, moderate emphasis = 2, strong emphasis = 1. While all statements with the letter "b" which referred to inquiry oriented teaching were rated as: no emphasis = 0, slight emphasis = 1, moderate emphasis = 2, strong emphasis = 3. Only one statement of each instructional feature was checked to indicate the appropriate response to the specific videotaped classroom observational segment concerning that instructional feature.

The researcher and a co-coder rated these classroom videotapes independently. The total scores of the instructional practice for each participant teacher were added and a percentage for each teacher was calculated. To identify teachers' instructional teaching approaches, 35% or below of the total score was operationalized as traditional or expository oriented, while 65% or more was operationalized as inquiry-oriented.

Raters Training Procedures for ISIF: A pilot administration of ISIF was conducted for two biology teachers to train the co-coder and establish interrater reliability. An overall interrater agreement of 90% was found between the author and the co-coder. Also, a percentage of item agreement of 85% between the raters was calculated for each item.

2- The Nature of Scientific Knowledge Scale (NSKS): The Nature of Scientific Knowledge Scale (NSKS) was developed by Peter Rubba (Rubba & Anderson,1978) to measure the nature of science. This instrument consists of 48 discriminating-reliable combinations of items. Subscales are composed of eight items, four positive and four negative, corresponding to each of the factors in the instrument. The subscales are: amoral, creative, developmental, parsimonious, testable, and unified. Three philosophers of science judged the model's soundness and found it as an inclusive model of the nature of scientific knowledge. The subjects responded to the items by using a five point Likert scale labeled "strongly agree," "agree," "neutral," "disagree," "strongly disagree." A maximum score of 40 points for each subscale and 240 points for the entire NSKS is possible.

The reliability coefficients for overall pretest and posttest scores were calculated using Cronbach's alpha internal consistency coefficients (posttest = 0.87; Pretest = 0.75). This reliability indicated that the NSKS scores could objectively and reliably discriminate between groups in this study. These reliability coefficients were similar to reliabilities in previous research with similar sample size (Forawi, 2000; Meichtry, 1992). The content validity of the NSKS items was judged by a panel of experts during the sixth set of its development. The construct validity of the instrument was examined after its development by testing an anticipated difference in their instructional backgrounds. An expost facto research design was used to collect evidence of NSKS construct validity (Lederman, 1992).

Data Analysis

The data of the NSKS overall scores from pretest and posttest were tested for each group separately. The posttest results were compared across groups to determine:

1. If the use of inquiry teaching by teachers with low understanding of the nature of science will increase students' understanding of the nature of science.

2. If the use of inquiry teaching by teachers with high understanding of the nature of science will increase students' understanding of the nature of science.

3. If the use of the Biological Sciences Curriculum Study and the use of inquiry teaching approach by teachers with high understanding of the nature of science will increase students' understanding of the nature of science.

4. If all groups will exhibit similar results.

The results of the questionnaire analysis served quantitatively to indicate which variables [redacted]ly related to changes in students' understanding of the nature of science. Because the groups were not randomly assigned and therefore may not [redacted] using an analysis of covariance (ANCOVA) by the method of unweighted means. This procedure allows for necessary adjustments between groups when testing data for significance. The seven null hypotheses to be tested were as follows:

Hol: There will be no significant main effect for teachers' understanding of the nature of science.

Ho2: There will be no significant main effect for instructional strategy.

Ho3: There will be no significant main effect for curricular content (Textbook).

Ho4: There will be no significant interaction between teachers' understanding of the nature of science and instructional strategy.

Ho5: There will be no significant interaction between teachers' understanding of the nature of science and textbook.

Ho6: There will be no significant interaction between instructional strategy and textbook.

Ho7: There will be no significant interaction among teachers' conceptions of the nature of science, instructional method, and textbook.

Results and Discussion

The statistical analysis focused on the change of students' pretest to posttest scores. The three main treatment variables investigated in the ANCOVA were: teachers' understanding of the nature of science (Tnos) high vs low; the instructional strategies (Inst) inquiry vs traditional; and textbooks (Text) BSCS vs NonBSCS. Data collected from the NSKS questionnaire were scanned by the computer and the use of the Statistical Package for the Social Sciences (SPSS). The quantitative analysis included two sections: Results of ANCOVA Analyses.

Results of ANCOVA Analyses:

This section focused on the analyses of the major hypotheses by the use of the analysis of covariance (ANCOVA) measure. The covariance design was used in order to measure the change of pretest to posttest score means on the overall Nature of Scientific Knowledge Scale (NSKS). This procedure was considered to be an appropriate method for determining differences among intact groups' means through the use of several criterion measures in this study. All seven tests were performed with an overall alpha 0.05 in order to control for any simultaneous error rate inherent in multiple testing designs. The analysis of covariance design was used to test the above seven null hypotheses and their alternatives.

In order to show that the inquiry teaching approach was effective, and that the interaction of teachers with high understanding of the nature of science who used inquiry teaching approach and the BSCS textbook was effective, it was necessary to show that these experimental groups improved in the NSKS posttest scores. The overall mean was found to be significantly greater for the posttest scores, (posttest mean = 172.00, pretest mean = 156.00). The standard deviation and range for the overall scores were also shown to be higher from pretest to posttest.

The summary of the analysis of covariance shown below in Table 1 represents the main effects and the interaction effects results among the three independent variables on the dependent variable (overall NSKS scores) in this study. Interpretations for these results follow.

Table I: ANCOVA Tests of Significance for the Main and Interaction Effects

For Students' Overall Posttest Scores (N=320)

Source	SS	DF	MS	F	Sign. of F
Teachers' NOS	31602.26	1	31602.26	153.50	.000****
Instruction	16499.46	1	16499.46	80.12	.000****
Textbook	15318.46	1	15318.46	74.38	.000****
TNOS by INST	573.03	1	573.03	2.78	.096
TNOS by TEXT	3935.62	1	3935.62	19.11	.000****
INST by TEXT	1250.68	1	1250.68	6.07	.014**
TNOS by INST by TEXT	1616.23	1	1616.23	7.85	.05*

* p <.05 *** p<.01 **** p<.0001

Ho1 Teachers' Understanding of the Nature of Science (Tnos):

A significant main effect for teachers' understanding of the nature of science was found confirming H1 [F(1,320) = 153.46, (p < .000)]. The students in the experimental groups who were taught by teachers who had a higher understanding of the nature of science as measured by the NSKS instrument were found to perform better than the students in the control groups who were taught by teachers with a lower understanding of the nature of science. This result is consistent with previous research on the nature of science (Lederman, 1992; Mattews, 1997).

Ho2 Instructional Strategy (Inst):

A main effect for instructional strategy was found to be significant [F(1,320) = 80.12, (p < .000)]. As hypothesized in this study, students taught by teachers using inquiry-oriented teaching methods would exhibit higher understanding of the nature of science than students who were taught by traditional methods. Previous research revealed that the inquiry or indirect teaching approach enhances students' achievement (Flick, 1997; DeBoer, 1991). The inquiry teaching method was found, in this study, to be an appropriate teaching method to develop better understanding of the nature of science in students as measured by the nature of scientific knowledge scale (NSKS) instrument. This result is similar to the finding of a study by Haukoos & Penick (1983) which indicated that students in discovery-oriented classes were found to make significant gains in understanding science processes and learning of science information as measured by the Science Process Inventory.

Ho3 Textbook (Text):

The third hypothesis of this study was that students who were taught by using the biological sciences curriculum study (BSCS) textbook would exhibit greater understanding of the nature of science than students taught by using textbooks other than the BSCS (nonBSCS). The main effect for textbook was found to be significant [$F(1,320) = 74.38$, ($p < .000$)]. The research reviewed in this study suggested that for the majority of high school students science curriculum will be their only formal exposure to biology as a science. Therefore, the BSCS textbook is intended to convey the procedures and conceptions that best characterize modern science (BSCS, 1990).

In contrast to a study by Meichtry (1992) which found no significant difference of BSCS textbooks and nonBSCS textbooks for enhancing middle school students' understanding of the nature of science, the results of the present study showed that the BSCS textbook is related to the instrumentalist orientations of the nature of science for high school students. Four additional important findings for the two-way interaction effects are presented as follows:

Ho4 Teachers' Understanding of the Nature of Science and Instructional Strategy (Tnos X Inst):

There was no significant difference found for teachers' understanding of the nature of science and instructional strategy (Tnos X Inst) [$F(1,320) = 2.78$, ($p < .096$)]. Consistent with similar findings of Duschl and Wright (1989), this result showed no significant relationship between teachers' understanding of the nature of science and classroom practice. The author suggested that it may be reasonable to expect, in many cases, factors other than the teachers' conceptions of the nature of science, such as curriculum constraints, administrative polices, level of students, etc., that influence the choice of instructional strategies to enhance students' understanding of the nature of scientific knowledge.

Research indicated that the interaction effect of many variables is needed for the development of students' understanding of the nature of science (Meichtry, 1992). It may not be enough to combine teachers' understanding of the nature of science with their instructional strategies to enhance student understanding of the nature of science. Other major factors such as the curricular content may play an important role in this process.

Ho5 Teachers' understanding of the Nature of Science and Textbook (Tnos X Text):

The interaction of teachers' understanding of the nature of science and textbook was found to be significant [$F(1,320) = 19.11$, ($p < .000$)]. As hypothesized, the students taught by teachers' having a higher understanding of the nature of science and using the Biological Sciences Curriculum Study textbook would exhibit higher understanding of the nature of science than the students in the control groups. This result supports the previous research findings that the use of the BSCS biology text enhances students' understanding of the nature of science especially when combined with other factors affecting the understanding of the nature of science (Meichtry, 1993).

Earlier research efforts by the National Science Foundation attempted to ameliorate the problem of the relationship of teachers' and students? understanding of the nature of science. It was concluded that teachers' understanding of the nature of science influences students' understanding of the nature of science. This study indicated that teachers with high understanding of the nature of science helped to improve their students' understanding of the nature of science especially when combined by the use of curriculum designed to enhance the understanding of the nature of science such as the Biological Sciences Curriculum Study textbook. In this study, the use of the Biological Sciences Curriculum Study by teachers' with high understanding of the nature of science developed on students a higher understanding of the nature of science more than the students in the control groups.

Ho6 Instructional Strategy and textbook (Inst X Text):

The two-way interaction between instructional strategy and textbook yielded a significant difference [$F(1,320) = 6.07$, ($p < .01$)]. It was hypothesized that students who were taught by inquiry-oriented teaching methods and who had used the Biological Sciences Curriculum Study textbook would exhibit higher scores on the nature of scientific knowledge scale instrument than the students in the other control groups.

In earlier research, curricular material was found to be an important factor for enhancing students' understanding of the nature of science when utilized with an effective teaching strategy (Lederman, 1992). However, the present study indicated that the Biological Sciences Curriculum Study interacted with the inquiry teaching method to develop a higher understanding of the nature of science on tenth-grade students than the interaction of non-BSCS textbooks and traditional teaching methods. This finding supported the instructional strategy main effect result that the inquiry teaching was found to best develop students' understanding of the nature of scientific knowledge in the present study.

Ho7 Teachers' Understanding of the nature of science, Instructional strategy, and Texbook (Tnos X Inst X Text):

The three-way interaction among teachers' understanding of the nature of science, instructional strategies, and textbook provided a significant difference [$F(1,320) = 7.85$, ($p <$

0.05)}. The major research question of this study was to investigate the combined interaction effects of three independent variables: teachers' understanding of the nature of science, instructional strategy, and textbook, on students' understanding of the nature of science. The result showed that the students who taught by teachers' with high understanding of the nature of science, who used the inquiry teaching approach and the Biological Sciences Curriculum Study (BSCS) textbook, developed the greatest understanding of the nature of science than the other groups. Research of the nature of science has been remiss by not studying the interrelationships among such major variables. The present study has filled this gap within the limits of generalization.

Conclusions and Implications

In summary, the teachers with high understanding of the nature of science were found to reflect the instrumentalist nature of science in their teaching practices. The use of frequent inquiry methods was, therefore, seen as a skill necessary in developing instrumentalist orientations of the nature of science. Also, teachers in this study incorporated a variety of text materials in their classes that were found to be related to promoting the instrumentalist nature of science. Therefore, understanding the instrumentalist nature of science was demonstrated through teachers' views regarding the nature of science, inquiry teaching, and the use of the Biological Science Curriculum Study (BSCS) textbook.

Implications of the Study:

One implication made possible by the results of this study is the importance of the instructional strategy in promoting students' understanding of the nature of science. An emphasis on teachers' conceptions of the nature of science and their instructional strategies, as demonstrated by this investigation, is considered to be an important area for further study. Other instructional modes, which induce conceptual change based on a constructivist view of learning, may be investigated to examine their effects on students' learning and understanding of the nature of science.

The mere use of the appropriate teaching method by teachers with high understanding of the nature of science is no guarantee that such understanding will develop. Although teachers' conceptions of the nature of science and the inquiry teaching approach may be of importance, other interaction factors, such as the curricular content, are needed to develop more understanding of the nature of science on students. In reference to the second question, the present study suggests that enhancing students' understanding of the nature of science should be achieved by combining teachers' conceptions of science, their instructional strategies, and textbooks. An implication of this result may be made by extensively examining the interaction of these variables in a larger population.

There may be significant differences in students' understanding of the nature of science with respect to the interaction between teachers' conceptions of the nature of science and instructional strategies. Although the difference was not statistically significant between experimental and control groups for the interaction effect of the combinations of teachers' understanding of the nature of science and instructional strategy for this analysis, definitive conclusions with respect to this effect will therefore need the support of further research.

From the results of this study, students' understanding of the nature of science can no longer be linked directly to teachers' understanding of the nature of science, instructional strategies, or textbook, but to the effective interaction among all these variables. The nature of science and its interaction variables needs to be made explicit in teacher education programs. Unless preservice teachers are provided with specific and planed opportunities to practice the implementation of views of the nature of science into the classroom many of the benefits anticipated may be lost. Research to test this hypothesis is needed.

The outcomes of this study open a new research line in understanding teachers' and students' conceptions of the nature of science. It does not end the efforts of the research on the nature of science. However, this study advances the opportunity of further research for studying the interaction of variables of the nature of scientific knowledge.

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